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Attachment 1

Summary

The GEM Waste-to-Energy system provides a proprietary solution for the thermal conversion of non-recyclable paper, cardboard, wood, plastic, food, and non-compostable agricultural waste into heat to be used by the host facility, thereby reducing the costs associated with energy and land filling. This system utilizes gasification (not incineration) technology to convert waste into distributed and clean energy. The system readily integrates into processing streams for institutions, businesses, and the military and provides a highly efficient and regulatory friendly means to derive more value from refuse.

The GEM Waste-To-Energy system is an integrated, standalone system consisting of three major components. These modular components are 1.) The Solid Waste Pre-Processor Module, 2.) The Gasifier Module and 3.) The Back End Option Module (Boiler). When integrated, the GEM Waste-To-Energy system provides a turnkey, alternative energy source that requires no segregation of food waste and has the ability to handle up to 3 tons per day.

The physical footprint of the GEM Waste-To-Energy system makes it portable via industry standard trucking methods. The Gasifier and Solid Waste Pre-Processor reside within a single 8ft x 9.5ft x 48ft shipping container. The Back End Option Module (boiler) is located in a separate 8ft x 8ft x 20ft container to convert the potential chemical energy of the syngas into heat to be used by the facility.

For operation at the Plymouth County Correctional Facility the GEM will operate approximately 8 hours each day to process the waste generated by the facility into energy. The facility generates about 1 ton of material each day which is currently compacted and hauled. Recyclable materials such as paper, cardboard, plastic, metals and glass are separated from the waste in the facility and will continue to be recycled during GEM operation.

Illustration 1 provides a picture of the GEM Waste-To-Energy system as described above.

42 Nagog Park Suite 110
Acton, MA 01720
www.mswpower.com
Ph: 978-264-0679 Fx: 866-337-5814

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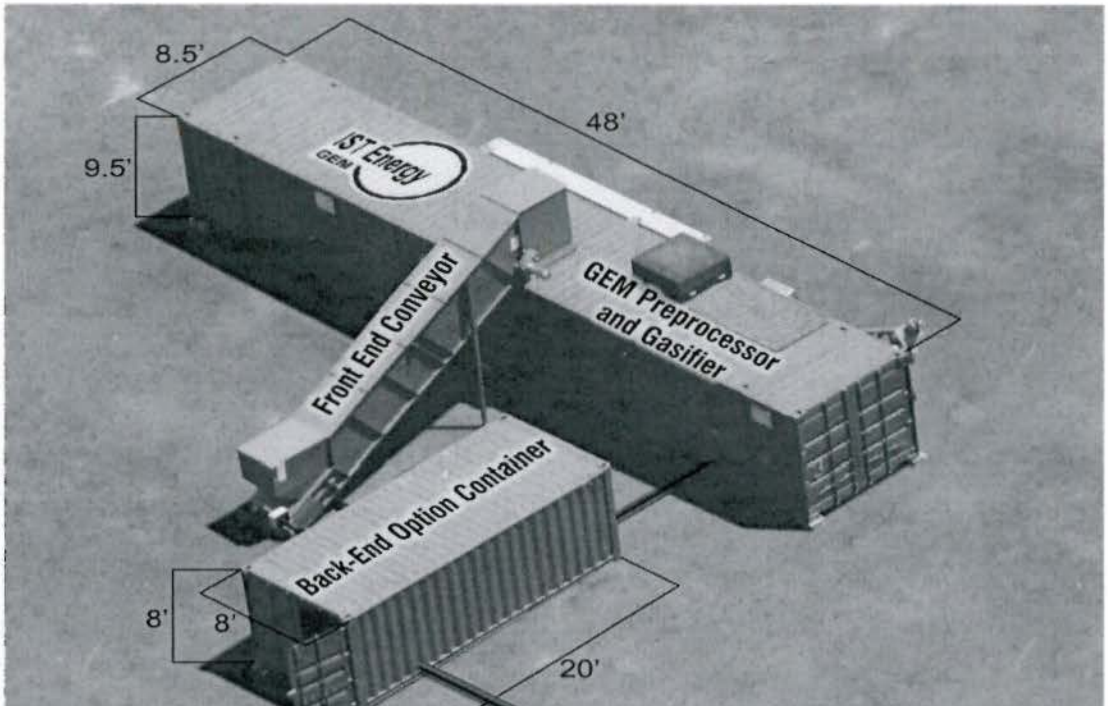

Illustration 1 – GEM Waste-To-Energy system On-Site

Equipment Operation

For the duration of the pilot operation of the system at the Plymouth County Correctional Facility, IST Energy will own and operate the equipment. During this pilot operation, waste normally directed to the existing compactors for waste hauler removal will be brought to the waste-to-energy system. IST Energy personnel will oversee the operation of the equipment. All maintenance procedures and waste handling into the waste-to-energy system will be conducted by IST Energy staff.

The Plymouth County Correctional Facility generates about 1 ton of waste material hauled for disposal each day. This waste is primarily cafeteria waste and includes plastic packaging for inmates who are delivered meals to satellite locations. Other waste from the facility includes office waste from correctional staff and inmate generated waste from the cells.

The existing recycling program at the Plymouth County Correctional Facility will continue to divert recyclables. The system in place is inspected by Mass DEP and the Department of Corrections for compliance with the waste ban.

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During this pilot it is anticipated that the waste-to-energy system will operate for eight hours each day to convert the waste generated by the facility into energy. The system will be started Monday through Friday in the morning (at approximately 8am) and operate until the days waste is converted (typically within 8 hours). Waste will be delivered after each meal of the day. The IST Energy staff will operate the waste-to-energy system 5 days of each week.

The ash produced by the gasifier will be periodically TCLP tested to verify that it can be disposed in a MSW landfill. It is not anticipated that any toxic leachates will be found in the feedstock material or the ash because of the controlled environment the waste is being generated from.

The system is controlled by a PLC based control system. Feedstock is added by the operator when feedstock level indicators show that the system is ready for additional material. Extensive operating variables are measured throughout the entire process. The control system is designed to optimize material processing while minimizing power usage within the system.

Waste Pre-Processor

The waste pre-processor begins by shredding the feedstock. A four shaft rotary shredder is used to reduce the feedstock material (waste) piece size to a maximum of 20mm. The amount of material in the shredder is electronically controlled so if there is no material to shred, it is shut off. This electronically controlled shutdown logic is applied to all processing steps within the waste-to-energy system. If there is no material to process, that portion of the system is automatically shut down to reduce energy consumption and overall system parasitic loss. From the shredder, material is conveyed to the dryer. The material passes by a continuous moisture sensor before going into the drying unit. The moisture content will dictate how much hot air should be supplied to the dryer. The heat is developed from a heat recovery process (heat exchanger cooling the produced syngas) in the gasifier system and is ducted to the dryer. The moisture level of the outlet of the dryer is measured to ensure proper drying occurred. If the product leaving the dryer is out of spec the control system will adjust the retention time of the material in the dryer to correct. Undesirables are then separated using a density separator and then the remaining material is compressed into fuel pellets 12mm in diameter and 20-40mm in length.

The amount of material which is turned into pellets is electronically weighed so throughput of the pre-processor and gasifier can be quantified.

The amount of current on all motors is monitored to determine loading condition of each processing step. If any motor begins to cross its normal operating threshold an alarm condition is signaled and the system will continue to monitor the motor until the system either comes back down to normal operating amperage or increases to a fault condition. If a system faults, the faulted operation and all prior operations are automatically suspended until the fault is corrected. The waste pre-processor is capable of processing 3 tons of material in 12-14 hours. This will maintain a duty cycle of the system within 50%-60%. One ton of feedstock material supplied from the Plymouth County Correctional Facility will be processed into fuel pellets within 4-5hours of operation. This one ton of feedstock will result in approximately 1600lb of pellets for the gasifier to convert into syngas because of the moisture removed in the Pre-Process dryer.

Gasifier

A downdraft gasification system is used to convert the solid fuel pellet into a synthetic gas product. It is important to maintain an optimal temperature profile within the gasifier to produce the highest carbon conversion rate and lowest tar output product. There are temperature probes in each of the nine zones of the gasifier to ensure a consistent temperature profile.

Temperatures are electronically maintained at the proper levels within the gasifier by adjusting the amount of ambient air being drawn into the gasifier at different vertical heights. Seven of the nine zones have controlled secondary air introduced into the gasifier to control the different chemical reactions within the gasifier. These zones control the four major reaction schemes in the process. The first is a drying stage where the pellets are in a zone above 100^{C} and moisture is removed. The material then enters a pyrolysis stage where the volatile matter is removed from the pellet in the form of gas. The other product of this process is char. The pryloysis stage operates between 400 and 800^{C}. The next part of the reactor combusts the gasses developed in the pryloysis stage and performs char reduction. This process develops CO_2 and H_2O as well as reduces the remaining char material. This stage operates at temperatures between 1000 and 1200^{C}. The final stage of the reactor performs a reduction reaction where CO_2 and H_2O are converted into H_2 and CO. This is done when the gas enters a region of the reactor where oxygen is absent and the high temperature and char allow for the reduction reaction to occur.

The product that leaves the reactor consists of CO, H_2, CH_4, N_2, CO_2 and H_2O. The pressure differential across the base of the gasifier is also electronically monitored and the vacuum adjusted to maintain the proper gas pressure and velocity within the entire system. Since the entire gasifier system is operated under negative pressure, there are no emissions released during the process. The synthetic gas (syngas) goes through several conditioning steps to provide a suitable product for downstream use. The conditioning consists of particulate filtering and syngas cooling.

During startup and shutdown of the gasification system the syngas generated is flared due to the low heating value of the gas during these transient operations. If the syngas heating value is too low to maintain self-sustaining ignition, propane may be added to the gas to ensure complete combustion of the syngas. When the gasification system has reached steady-state operating conditions the syngas is directed to the boiler to harvest energy for the facility.

Boiler

The syngas generated by the gasifier is piped from the gasifier through steel piping to a boiler located in another container. The syngas is fired in a Weil McLain Series 88 boiler using an Eclipse ThermAir Model TA200 burner. This combination allows efficient energy harvest of the syngas. A propylene glycol/water heat transfer liquid loop is used to pre-heat the hot water circulation system within the jail. This reduces the overall heating load for the water heaters located in the jail and reduces natural gas usage for the facility.

With the efficiency of the boiler/burner combination and the heat transfer loop it is expected that the boiler running on syngas will be able to supply the Plymouth County Correctional Facility with 1.0 MMbtu/hr (or 10 Therms/hr) of heat in the existing hot water system during the pilot program.

Syngas generated by the gasifier is the only fuel which is combusted in the boiler.

Waste Material Sources

The waste material for this system will originate from jail and support buildings.

Waste materials will be collected from the cafeteria as well as the waste form the seven individual pods of the jail. This material is currently directed to the compactors as waste and hauled by the contracted waste hauler.

Waste material from the offices at the Administration Building will also be directed to the GEM Waste-To-Energy system.

The existing recycling program will continue to divert materials listed on the Mass DEP waste ban for recycling.

The facility generates approximately 1 ton of waste each day. Samples analyzed have shown the average moisture content of the material to be 35%. The material will be dried to a moisture content of 10%-15% internally in the waste Pre-Processor before being densified into pellets. The GEM Waste-To-Energy gasifier is capable of gasifying 200lb of material in one hour. At this rate, the one ton of material dried should yield 1600 lb of pellets which will be converted to syngas in the gasifier in 8 hours of gasifier operation.

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Waste Material Content

IST Energy expects the contents of the waste stream to include food scraps, non-recyclable paper/cardboard and certain plastics. Dues to the nature of the facility the waste generated is predictable and controlled by the operators of the facility (Sherriff's Department).

The plastics are limited to non-recyclable polyethylene teraphthales, high density polyethylene, low density polyethylene, polypropylene and polystyrene packaging.

Energy will not be accepting any industrial, construction and demolition and/or any hazardous waste (including biohazards).

Any material collected during a 24 hour period which cannot be processed by the GEM Waste-To-Energy system will be disposed in the existing compactors.

Table 1 below identifies what Energy predicts the composition of the waste stream will be.

Table 1 - Expected Waste Composition for the GEM

Waste Component	Weight %	Heating Value (BTU/lb)
Food	25	2,500
Paper/cardboard	35	8,000
Plastics	35	18,000

Unacceptable Materials

IST Energy has defined the materials unacceptable for the GEM Waste-To-Energy system as any construction and demolition waste, PVC pipe, Plastics # 7 (labeled as other plastics) and hazardous wastes.

To ensure Energy is putting forth its best effort to ensure these components are not present in the waste stream, there will be a quality check of every bag performed to ensure these materials are not present. This process will be modified as required to ensure unacceptable materials are not included in the waste stream. The waste from the facility is collected in clear plastic bags for security reasons and allows Energy to verify contents before they are placed in the GEM Waste-To-Energy system

General Recycling

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It's the goal of IST Energy to convert post consumable materials that are not suitable for recycling into heat for the facility. As part of IST Energy's ongoing goal to provide clean, safe energy for the future, it recognizes the important role recycling programs have in sustaining the environment.

It is not IST Energy's intention to replace any customer's current recycling program.

Emissions

Hazardous Air Pollutant Emission

Using the AP-42 Emission Factors the Potential to Emit HAP for the Plymouth County Correctional Facility were calculated based upon the equipment installed in the facility. The emission sources for the facility are listed below:

Device Description	Quantity at facility	Energy input
Roof Top Heating/AC unit	65	250,000 Btu/hr
Water Heater	2	2,000,000 Btu/hr
Water Heater	2	3,200,000 Btu/hr
Diesel Stand-by Generator	2	10,500,000 Btu/hr

For these calculations a heating value of 1020 Btu/scft was used to convert the heat input of each device to a volume measurement of natural gas. For the GEM system, the syngas generation volume of 130scfm was used. Because the AP-42 Emission Factors do not contain data on syngas, natural gas factors were used for the GEM output.

The calculations for the estimated potential emissions for the facility are part of this document package. For these calculations the assumed yearly operational hours for each stand-by generator is 500 hrs based upon the reccomendations in the 09-06-95 memo, Calculating PTE for Emergency Generators.

Greenhouse Gas Emissions

The combustion of syngas in the boiler is the source of air emission from the GEM waste-to-energy system. IST Energy uses a Mass Spectrometer (MS) to determine the gas composition of the syngas. Below is a summary of the results:

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Component	V_A/V Vol%	M_A MW	$M_A(V_A/V)$ MW*Vol%	m_A/m	C wt%
CO	10.00%	28	2.80	12.6%	5.4%
CO_2	7.00%	44	3.08	13.8%	3.8%
CH_4	11.00%	16	1.76	7.9%	5.9%
H_2	18.00%	2	0.36	1.6%	
N_2	44.00%	28	12.32	55.3%	
O_2	1.00%	32	0.32	1.4%	
H_2O	9.00%	18	1.62	7.3%	
	100.00%		22.26	100%	**15.1%**

The MS unit provides the results in Vol %. In order to determine the overall carbon content of the syngas, one must convert to a mass percentage based upon the molecular weights (MW) of the component. Therefore, there are 0.151 lbs of carbon for every pound of syngas. By multiplying the ratio of carbon in carbon dioxide (44/12) to mass flowrate of carbon in the syngas, the result is the lbs CO_2/lbs syngas. Therefore, 0.151 lbs * (44/12) = 0.553 lbs CO_2/lbs syngas. The GEM operates at 130 CFM and 10" W.C pressure and 50^C. This results in a mass flowrate of 0.169 lbs/min. Mulitplying the mass flowrate of the syngas by the CO_2 production per pound of syngas results in the rate of CO_2/min.

0.5535 lbs CO_2 produced per pound of syngas * 0.1690 lbs/min of syngas = 0.0935 lbs CO_2/min. Converting lbs/min into lbs/year is as simple as multiplying the number by 1440. The result is 134.69 lbs CO_2/day or 0.0673 tons CO_2/day or 25 tons CO_2/year.

The overall greenhouse gas emission rate of the GEM is the production of 25 tons CO_2/year.

42 Nagog Park Suite 110
Acton, MA 01720
www.mswpower.com
Ph: 978-264-0679 Fx: 866-337-5814

HAP Emission Estimates	NG Heating Value 1020 Btu/scft		
Source Description and qty.		1 hr input 10^6 scf of gas	8760 hr input 10^6 scf of gas
Roof top units 65 - 15 ton units - 250 Mbh heat		0.000245098	2.147058824
2 MMBtu water heater		0.001960784	17.17647059
3.2 MMBtu Water heater		0.003137255	27.48235294
GEM Gasifier (130 CFM syngas)		0.0078	68.328

Pollutant	Emission Factor (lb/10₆ scf)	Emission Factor Rating	1 Roof Top Unit emission potential lb/yr	one 2MMBTU water heater emission potential lb/yr	one 3.2 MMBtu water heater emission potential lb/yr	1 GEM (w/ 2MMBtu boiler) Emission potential lb/yr
2-Methylnaphthalene	2.40E-05	D	0.00005	4.12E-04	6.60E-04	1.64E-03
3-Methylchloranthrene	1.80E-06	E	0.00000	3.09E-05	4.95E-05	1.23E-04
7,12-Dimethylbenz(a)anthracene	1.60E-05	E	0.00003	2.75E-04	4.40E-04	1.09E-03
Acenaphthene	1.80E-06	E	0.00000	3.09E-05	4.95E-05	1.23E-04
Acenaphthylene	1.80E-06	E	0.00000	3.09E-05	4.95E-05	1.23E-04
Anthracene	2.40E-06	E	0.00001	4.12E-05	6.60E-05	1.64E-04
Benz(a)anthracene	1.80E-06	E	0.00000	3.09E-05	4.95E-05	1.23E-04
Benzene	2.10E-03	B	0.00451	3.61E-02	5.77E-02	1.43E-01
Benzo(a)pyrene	1.20E-06	E	0.00000	2.06E-05	3.30E-05	8.20E-05
Benzo(b)fluoranthene	1.80E-06	E	0.00000	3.09E-05	4.95E-05	1.23E-04
Benzo(g,h,i)perylene	1.20E-06	E	0.00000	2.06E-05	3.30E-05	8.20E-05
Benzo(k)fluoranthene	1.80E-06	E	0.00000	3.09E-05	4.95E-05	1.23E-04
Butane	2.10E+00	E				
Chrysene	1.80E-06	E	0.00000	3.09E-05	4.95E-05	1.23E-04
Dibenzo(a,h)anthracene	1.20E-06	E	0.00000	2.06E-05	3.30E-05	8.20E-05
Dichlorobenzene	1.20E-03	E	0.00258	2.06E-02	3.30E-02	8.20E-02
Ethane	3.10E+00	E				
Fluoranthene	3.00E-06	E	0.00001	5.15E-05	8.24E-05	2.05E-04
Fluorene	2.80E-06	E	0.00001	4.81E-05	7.70E-05	1.91E-04
Formaldehyde	7.50E-02	B	0.16103	1.29E+00	2.06E+00	5.12E+00
Hexane	1.80E+00	E				
Indeno(1,2,3-cd)pyrene	1.80E-06	E	0.00000	3.09E-05	4.95E-05	1.23E-04
Naphthalene	6.10E-04	E	0.00131	1.05E-02	1.68E-02	4.17E-02
Pentane	2.60E+00	E				
Phenanathrene	1.70E-05	D	0.00004	2.92E-04	4.67E-04	1.16E-03
Propane	1.60E+00	E				
Pyrene b	5.00E-06	E	0.00001	8.59E-05	1.37E-04	3.42E-04
Tolueneb	3.40E-03	C	0.00730	5.84E-02	9.34E-02	2.32E-01
Metals						
Pollutant	Emission Factor (lb/10₆ scf)	Emission Factor Rating				
Arsenic	2.00E-04	E	0.00043	3.44E-03	5.50E-03	1.37E-02
Barium	4.40E-03	D	0.00945	7.56E-02	1.21E-01	3.01E-01
Beryllium	1.20E-05	E	0.00003	2.06E-04	3.30E-04	8.20E-04
Cadmium	1.10E-03	D	0.00236	1.89E-02	3.02E-02	7.52E-02
Chromium	1.40E-03	D	0.00301	2.40E-02	3.85E-02	9.57E-02
Cobalt	8.40E-05	D	0.00018	1.44E-03	2.31E-03	5.74E-03
Copper	8.50E-04	C				
Manganese	3.80E-04	D	0.00082	6.53E-03	1.04E-02	2.60E-02
Mercury	2.60E-04	D	0.00056	4.47E-03	7.15E-03	1.78E-02
Molybdenum	1.10E-03	D				
Nickel	2.10E-03	C	0.00451	3.61E-02	5.77E-02	1.43E-01
Selenium	2.40E-05	E	0.00005	4.12E-04	6.60E-04	1.64E-03
Vanadium	2.30E-03	D				
Zinc	2.90E-02	E				
		lb HAP/yr	0.19830	1.59E+00	2.54E+00	6.31E+00
		ton HAP/yr	9.91492E-05	7.93E-04	1.27E-03	3.16E-03
		65 RTUs HAP (ton/yr)	0.006444701			
		(2) 2 MMBtu Water Heaters (tons/yr)		1.59E-03		
		(2) 3.2 MMBtu Water Heaters (tons/yr)			2.54E-03	
GEM boiler HAP Estimates are based upon 130 cfm natural gas because AP-42 does not contain emission factors for syngas		GEM w/ boiler (tons/yr)				3.16E-03
		Total Potential HAPs from natural gas for existing facility (tons/year)			0.01057	
		Total Potential HAPs for existing facility with a GEM Gasifier (tons/year)			0.01372	

Standby Generator information

(2) CAT 3512 diesel	Diesel Engine input (MMbtu/hr)	10.05	
	Hours of operation/yr *	500	* Generators installed as stand-by/emergency generators use a 500 hour operational time for PTE calculations based upon the reccomendations in the 09-06-95 memo, Calculating PTE for Emergency Generators
Pollutant	Emission Factor (Fuel Input) (lb/MMBtu)		
Benzene b	0.000933	4.688325	
Toluene b	0.000409	2.055225	
Xylenes b	0.000285	1.432125	
Propylene	0.00258	Non-listed HAP	
1,3-Butadiene b,c	0.0000391	0.1964775	
Formaldehyde b	0.00118	5.9295	
Acetaldehyde b	0.000767	3.854175	
Acrolein b	0.0000925	0.4648125	
PM-10 *	0.31	1557.75	
Polycyclic aromatic hydrocarbons (PAH)	-- ------------------------		
Naphthalene b	8.48 E-05		
Acenaphthylene	<5.06 E-06		
Acenaphthene	<1.42 E-06		
Fluorene	2.92 E-05		
Phenanthrene	2.94 E-05		
Anthracene	1.87 E-06		
Fluoranthene	7.61 E-06		
Pyrene	4.78 E-06		
Benzo(a)anthracene	1.68 E-06		
Chrysene	3.53 E-07		
Benzo(b)fluoranthene	<9.91 E-08		
Benzo(k)fluoranthene	<1.55 E-07		
Benzo(a)pyrene	<1.88 E-07		
Indeno(1,2,3-cd)pyrene	<3.75 E-07		
Dibenz(a,h)anthracene	<5.83 E-07		
Benzo(g,h,l)perylene	<4.89 E-07		
TOTAL PAH	0.000168	0.8442	
Total HAP (lb/year)	lb/yr	1577.21484	
Total HAP (Tons/year)	Tons/yr	0.78860742	
HAP emissions calculated for a single generator	Two Generators onsite	1.57721484	Total potential HAP emission tons/yr

*	All of the PM-10 effluent is assumed to be HAP metals because there are no HAP metals in the AP-42 emission factors.

Plymouth County Correctional Facility Potential To Emit HAP Summary

Natural Gas Usage:	PTE HAP tons/yr
65 RTUs HAP	0.006444701
(2) 2 MMBtu Water Heaters	1.59E-03
(2) 3.2 MMBtu Water Heaters	2.54E-03
Standby Generators	
(2) CAT 3512 diesel	1.57721484
PTE Tons/yr Total	1.587784149
GEM unit using boiler (tons/yr)	3.16E-03
PCCF with GEM (tons/yr)	1.59E+00